

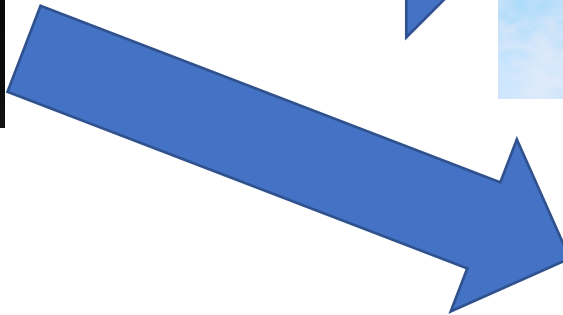
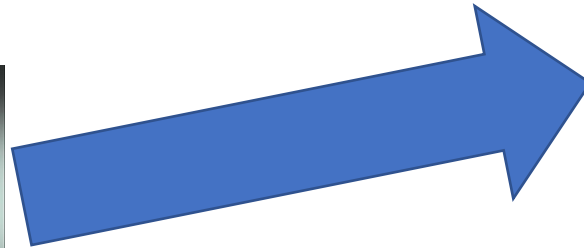
What do all of these aircraft have in common?



They all have one pilot (PIC)
controlling one Aircraft (1:1)

Remote control stations (GCS) and increasing autonomy will allow 1:many (1:M)

Remote ground control stations



Safety and efficiency may be enhanced by multiple GCS controlling multiple A/C (M:N)

Remote ground control stations



Background

- Playbook
 - Simulations
 - Flight Tests
- Working agreements
- NATO working groups
 - Supervisory Control of Multiple UAS
 - Human Autonomy Teaming
 - **Meaningful Human Control of AI based systems**
- Current Efforts
- Potential Collaborations

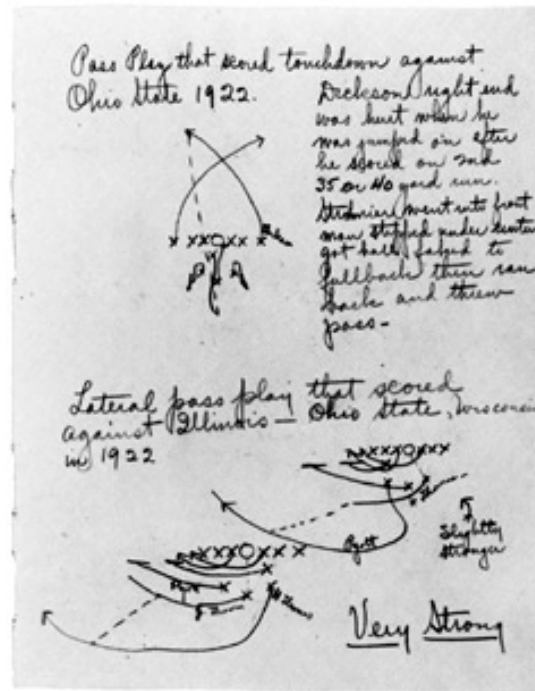
M:N

- Enable a single operator (or group of operators (M)) to control multiple vehicles(N) through human autonomy teaming (HAT) principles.

f(Nt, St, dist)

- *Neglect time f(automation, working agreements)*
- *Service time f(contingency management, playbook)*
- *Distro f(predictive timeline displays)*
- Quantify M:N
- Understand parameters
- Tools to support

Delegation Control: Playbook[®]



A page from Alonzo Stagg's 1927 Playbook

- Delegation: one way humans manage supervisory control with heterogeneous, intelligent assets
- Playbook[®]: one's means of delegation
- Plays: analogous to football
 - Quick commands – complex actions
- A Play provides a framework
 - References an acceptable range of plan/behavior alternatives
 - Requires shared knowledge of domain Goals, Tasks and Actions
 - Supervisor can further constrain/stipulate
- Potentially facilitates intuitive cooperative control of Unmanned Systems

Example: Troops in Contact Tango

Predator Provides Overwatch
and looks for egress routes

TANGO

Shadow provides situation awareness

Firescout
Does Quick Med
Drop



Levels of Automation Simulation

Example: Prosecute Target

Tools:

Arm laser → Lase target → Send coordinates to weaponized UAV → Toggle UAVs → Arm missile → Fire

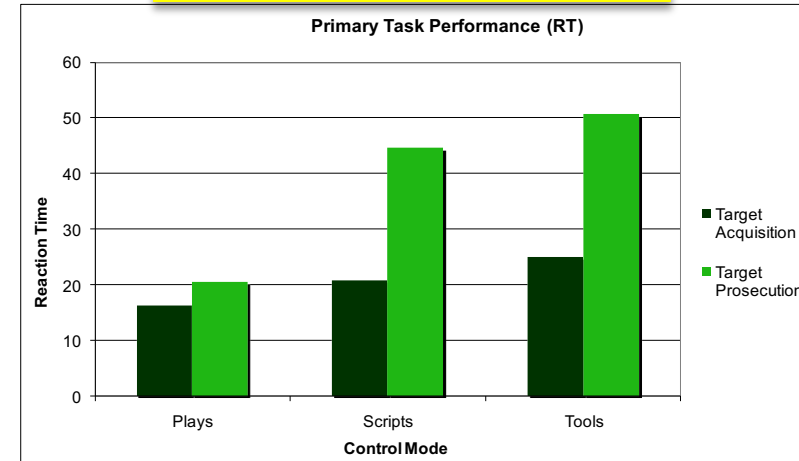
Scripts:

Select 'Lase' script → Toggle UAVs → Arm weapons → Fire

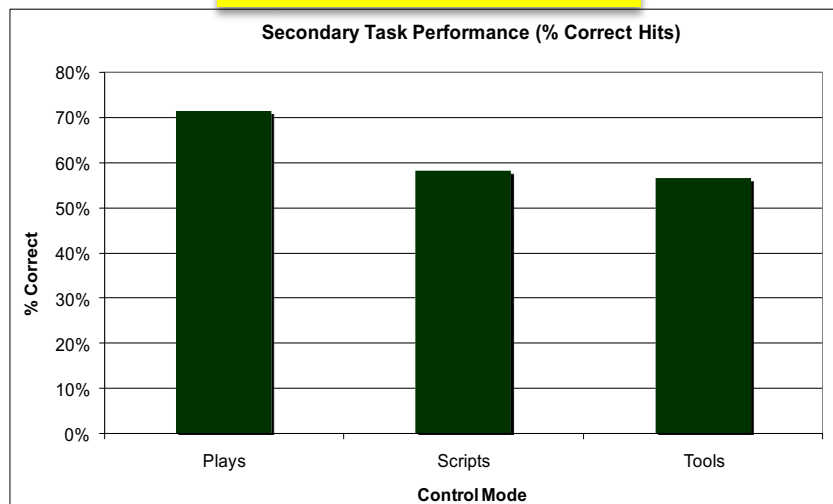
Plays:

Select 'Prosecute Target' play → Fire

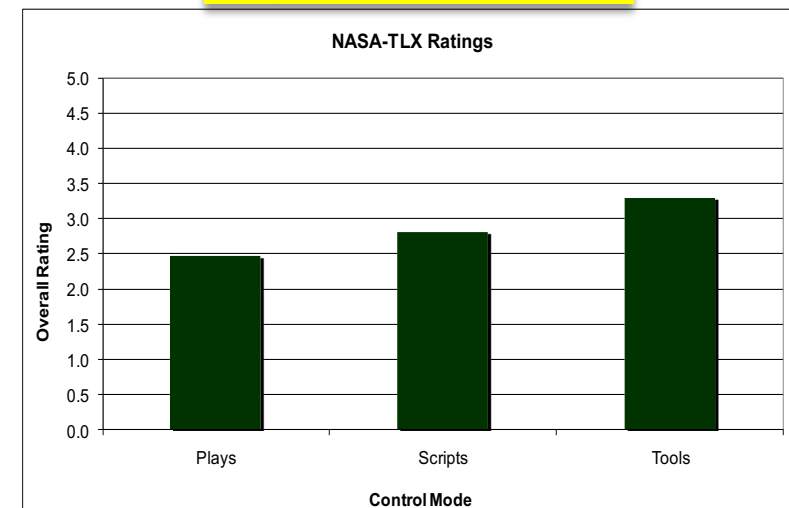
Shorter Reaction Time for Plays



Higher Accuracy for Plays



Plays had lower workload



Flight Demonstration 2009

Ft. Ord CA, 23 APR 2009

Goal:

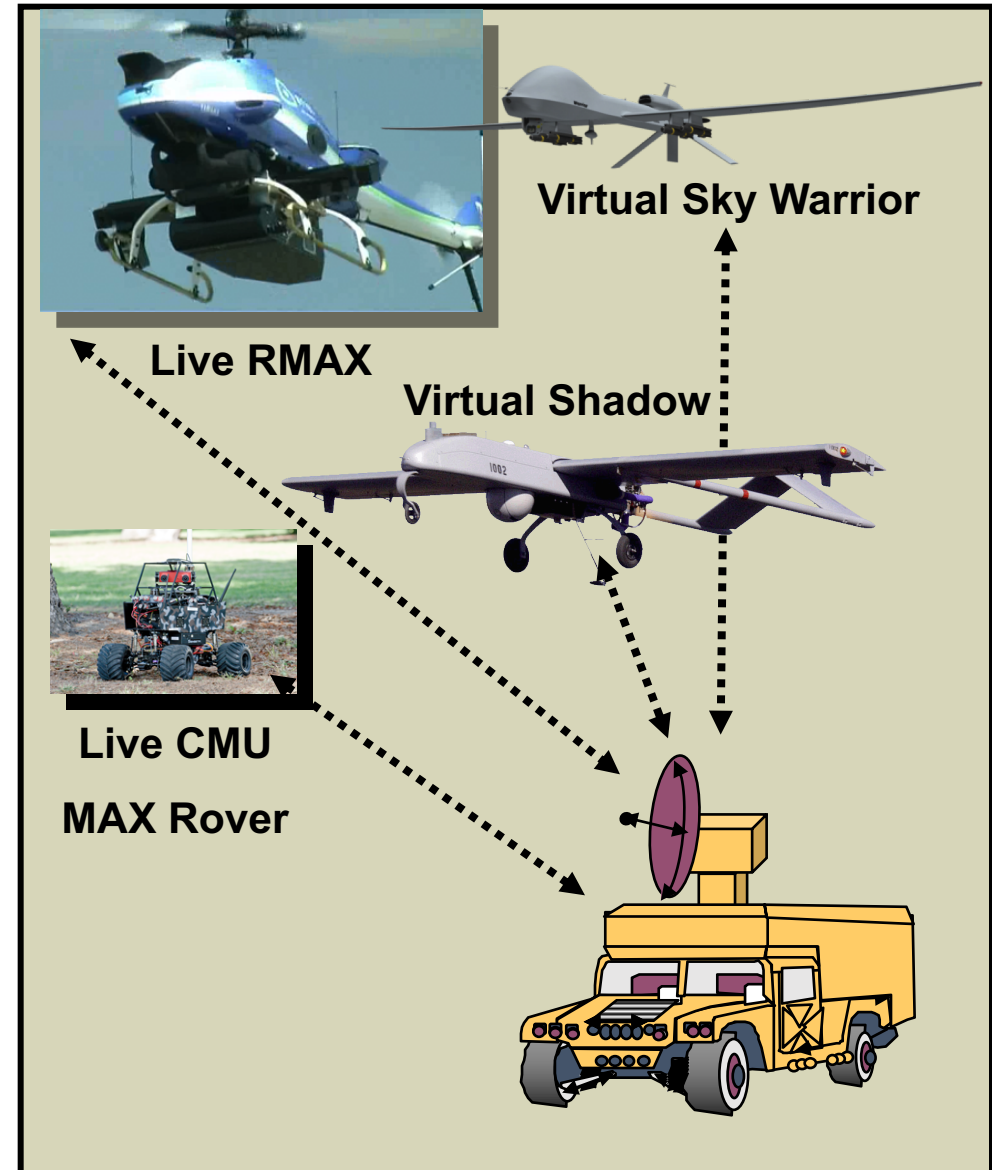
- Demonstrates initial proof of concept of Delegation Control (Playbook) in flight – supervisory control of multiple air/ground assets in MOUT Scenario

Method:

- Live/Virtual Demo – Controlling RMAX, CMU MAX Rover and 2 virtual UAS with Delegation Control
- Voice RGN Control (USAF)

Features:

- Delegation control human-machine interface supports control and monitoring 4 payloads
- Automation Transparency
- Live UGV-UAV coordination for slung load drop
- Reduced operator workload/high situation awareness



Flight Demonstration 2011

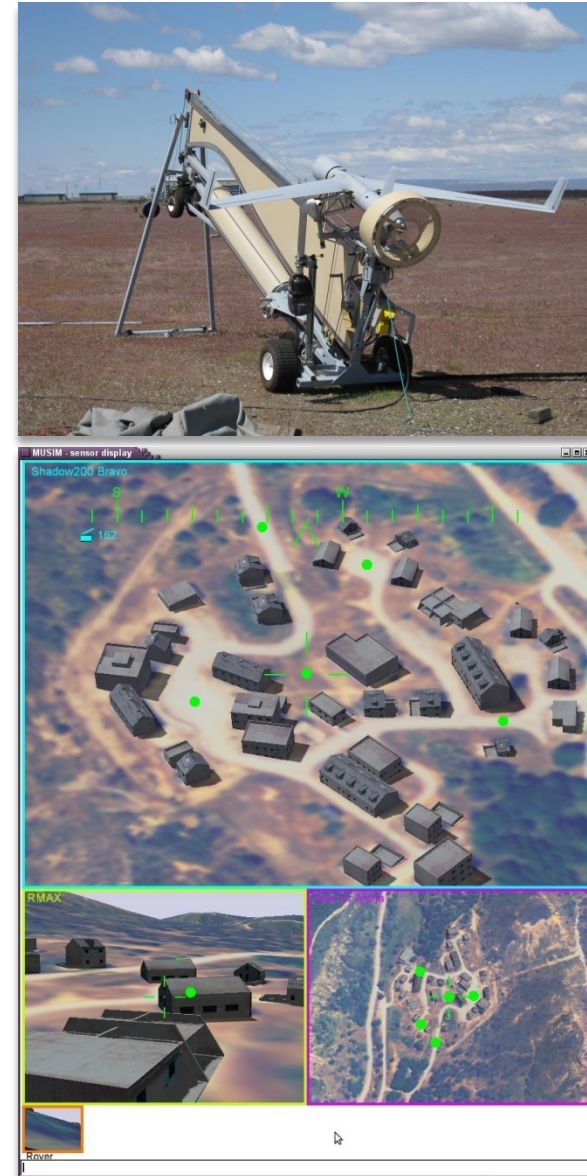
Ft. Hunter-Liggett CA, 19 May 2011

Purpose:

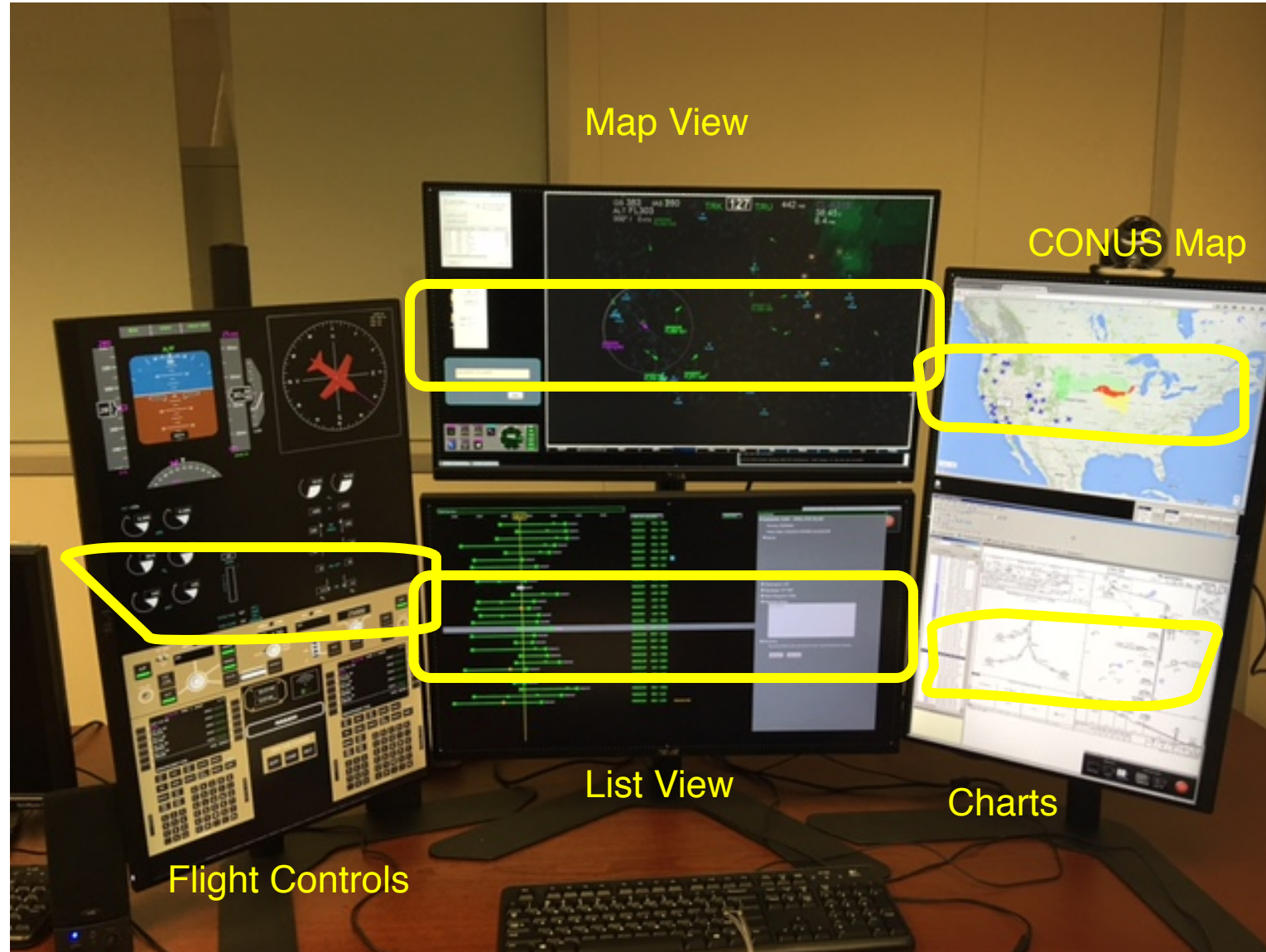
- Build on previous simulations and flight test examining single operator control of multiple heterogeneous ground/air unmanned systems through delegation control employment
 - Operator performance data collection/workload assessments
 - Heterogeneous flight assets: **Boeing Scan Eagle** and **Yamaha RMAX**; two virtual UAS
 - Testing in operationally relevant mission scenarios
 - Multi-sensor cross-cue in support of both targeting and convoy support
- Army AFDD/Boeing CRADA

Key Objective:

- Develop and test DelCon **Top Priority Plays**; route recon, convoy support, troops in contact



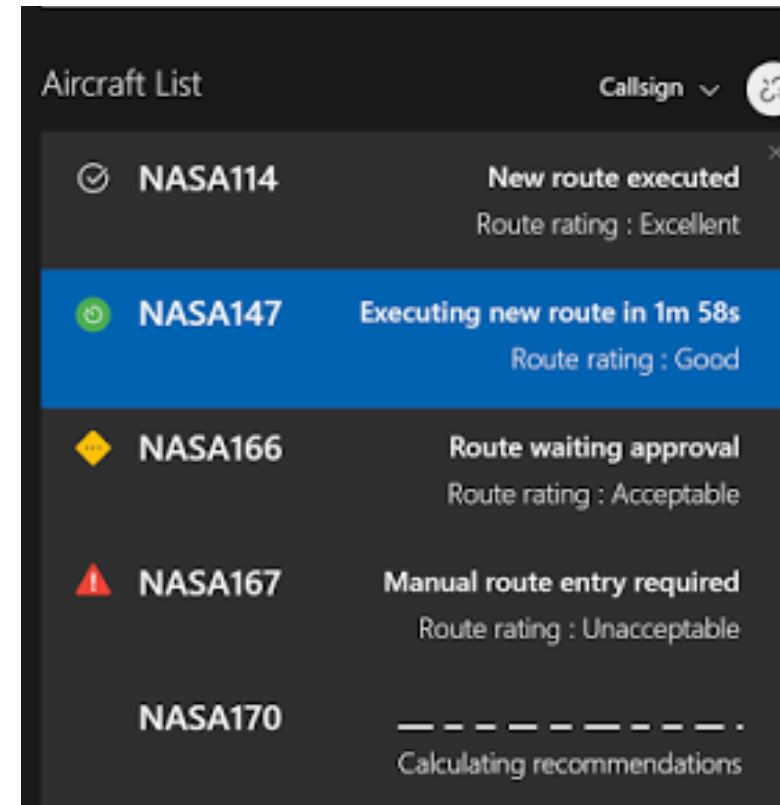
Ground Station Layout: Reduced Crew Operations



ALTA Action Phase

Based on working agreements, the Agent will do one of the following:

- [Auto] autonomously executes and informs operator
- [Veto] presents a solution which will be autonomously executed unless the operator intervenes
- [Select] presents multiple options for operator selection



Aircraft List		Callsign	
✓	NASA114	New route executed	Route rating : Excellent
🟢	NASA147	Executing new route in 1m 58s	Route rating : Good
🟡	NASA166	Route waiting approval	Route rating : Acceptable
🔴	NASA167	Manual route entry required	Route rating : Unacceptable
	NASA170	Calculating recommendations	

Working Agreements: A Path to Full Autonomy

- Working agreements allow the task structure to remain the same while the involvement of human operators decreases due to improvements in the automation and increases in trust

Current Efforts

- Scalability of UAS detect and avoid solution to multi-vehicle
- Two “Autonomous” Car companies
 - Contingency management
 - Teleoperator Safety Driver
- Food delivery
 - Small drone delivery
 - Initial goal; 1:4
 - Long term goal; 4:400

Human in the Loop (HITL) Simulation Facility

Vigilant Spirit Ground Control Station



ATC

Sim Manager Pseudo Pilot



Via
LVC



LAB set-up: Vigilant Spirit GCS



Loon – NASA Potential Collaborations

- Quantification of M:N
 - 1) Collect operational data (FY 20)
 - Neglect time, service time, distribution
 - Include datalink, vehicle response time, start-up time, transition time, etc.
 - 2) Empirical evaluation of CONOPS, contingency management (FY 21)
 - Modify lab; flight models, airspace
 - ID critical cases, contingencies
 - Changed RTCA, FAA use of empirical data in RTCA SC 228 MOPS & TSO's
- Trade space for operators is small
 - Plays for network wide events
 - Predictive time line display for workload management
- Standards/Regulators coordination
 - NASA as independent arbiter
 - RTT with FAA
 - RTCA/ASTM